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## Article

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Review

# Characteristics of Lead Users in Different Stages of the New Product Development Process: A Systematic Review in the Context of Open Innovation

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**Abstract:** Despite the promising ideas of lead users, the success rate of the open innovation process remains low if no proper personal characteristics are attached to the external contributor. The knowledge about the essential characteristic elements of lead users is crucial to select the right lead users in the early stage of the NPD. By filling the research gap, we performed a systematic literature review about the required personal characteristics of lead users. The resulting 45 studies demonstrated that diverse characteristics are required in different stages of an NDP which vary in the consumer and industrial context. According to our research results, we made a contribution to the theory by extending the lead user method in the form of a partial theory. We also found that in the case of incremental innovations, companies apply their technical knowledge and do not require additional expertise from users, while in the case of radical innovations, firms only involve external users with high technological competencies in the development stage of the NDP. We identified similarities and differences of the required lead users' personal characteristics in the consumer and industrial contexts. Thus, our study provides a better awareness for business leaders on the selection of lead users for their NPD process, reducing the time-to-market ratio of the product and increasing profit.

**Keywords:** open innovation; lead user; personal characteristics; new product development; co-creation; systematic review



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## 1. Introduction

Open innovation supports corporate growth and profitability. Firms are increasingly opening their boundaries and applying various methods to identify user innovations [1] and tap users' product knowledge and experience [2,3]. Successfully innovating firms involve users [4,5], customers [6] and patients [7] in the "fuzzy front end" of their new product development (NPD). Ref. [8] states that average users are not suitable for developing novel product attributes because they cannot accurately determine future market needs. Only leading-edge users with real-life usage experience can provide accurate information on the needs for product development. Quality information from lead users [9] and their systematic design freedom [10] results in better product development. von Hippel first defined the term lead user, then assigned two main attributes to identify them: "lead users face needs that will be general in a marketplace—but face them months or years before the bulk of that marketplace encounters them, and lead users are positioned to benefit significantly by obtaining a solution to those needs" [8] (p. 13). The high expected benefit and the superior trend position are also strong predictors for co-creation [11].

The lead-user method aims to identify and involve lead users to the NPD process as they are "at the leading edge of each identified trend in terms of related new products and process needs" and they "expect to obtain a relatively high 'net benefit' from solutions

to those needs” [8] (p. 798). All later adoptions of the lead user method contain these two crucial attributes of lead users [12–15]. The adaption of the lead user method by [16] consists of the following four steps: 1. start of the lead user process, 2. identification of needs and market trends, 3. identification of the lead user, 4. concept design and the start of co-creation. According to scholars, it is challenging to determinate lead users in the fuzzy front end of the NPD process [17–19] even with the existence of multiple identification methods [20–22].

While the lead-user method is suitable for the identification of lead users based on the two main attributes of ‘ahead of market trend’ and ‘high expected benefit’, it does not consider explicitly the personal characteristics elements of lead users, such as users’ knowledge, motivation, skills, behavior, experience, betweenness centrality, attractiveness, etc. Studies emphasize that the lead users’ personal characteristics are crucial for successful co-creation. According to [23], the contribution of individuals to the co-operation process varies strongly; therefore, the proper selection of lead users plays a critical role. This is in line with the findings of [24], which states that the characteristics of users differ significantly from the user type, typically involved in conventional research. Scholars emphasize the importance of selecting the right user profiles for the development process [25–27]. The authors [28] (p. 13) highlight the role of ‘the human factor’ and state that the synergy in innovation “can only be achieved if the right number of the right people are prepared to collaborate with each other” (ibid).

An increasing number of studies investigate lead users’ personal characteristics. Ref. [24] underlines the importance of imagination capabilities, openness to new technologies, high level of expertise and technological competencies. According to [29], consumer knowledge, use experience, locus of control and innovativeness are important antecedents of lead usersness. Refs. [17,30] highlight the importance of “local” (tacit knowledge) information. Ref. [31] finds a positive impact on willingness, task motivation, creativity components, and relevant product knowledge. Ref. [32] states that individuals’ creativity and personality play an important role in the determination of lead usersness. Ref. [33] finds that managers shall pay attention to the selection of the right users for idea generation of an innovation process. Ref. [34] emphasizes that improper customers may appear to offer benefits as experience sharing and improvement suggestions; however, their value is misleading due to the missing vital personal characteristics. Ref. [35] describes the case of failed innovation by ostensible users with a lack of essential characteristics.

Studies show that co-creation is an emerging phenomenon of contribution where customers are the central and essential part of the NPD process [36]. The participation of users has become crucial to realize successful innovation [37]. This kind of co-creation is different from the broader understanding of co-creation, which refers to co-creation experiences that includes the whole interaction between the customer and the firm, and it focuses on “creating an experience environment in which consumers can have active dialogue and co-construct personalized experience” [38] (p. 8). In our case, co-creation is also different from customer involvement to allow for a single point of idea exchange [23]. Co-creation is when lead users actively participate in all phases of the NPD, including idea generation, concept formulation, product development and test, market diffusion and post-launch activities [39].

As the personal characteristics of lead users have a high impact on the success of the open innovation process, the clear understanding of the required personal characteristics’ elements at different stages of the NDP is therefore crucial for managers to select the proper lead users for their NDP process. The relevance of the problem is judged by the evidence that managers aim to select the right lead users for their NPD depending on the level of lead user involvement in the NPD. In the case of high-level involvement, decision makers aim to reduce the gap of different professional backgrounds, different points of view between external contributors (lead users) and internal employees (engineers, product owners, etc.). The knowledge about the lead user characteristics in different stages of the NPD is relevant for making the right decision during the selection process of lead users.

Scientific articles usually investigate only one or some personal characteristic elements of lead users in a dedicated market context (consumer or industrial). Insights into what is important at different stages of the NPD is very scarce. Although these publications are of great scientific value, we found no study which comprehensively reviews the published peer-reviewed papers related to the personal characteristics of lead users in different stages of the NPD process. In order to fulfil this research gap, we carried out a systematic literature review (SLR) and report the findings in our study.

The authors defined three aims of the systematic literature review (SLR). The first goal is to create a narrow research question and systematically search, analyze and synthesize research results of the published literature between 2000 and 2020, taking account of the value and accuracy of the studies. The second aim is to report findings at different stages of the NPD process separated into consumer and industrial contexts, while the third one is to identify research gaps for further research, which requires additional exploration and investigation. To reach the above objectives, the following research question is formulated:

RQ: What personal characteristics of lead users’ managers need to consider in the selection process of lead users by considering each stage of the NPD process and the differences between the consumer and industrial segments?

We considered the lead user method as a basic concept to identify and involve lead users in the NPD process. We have assumed the missing link of the step of ‘selection of lead users based on their personal characteristics’ in the lead-user method between the steps of ‘identification of lead user’ and ‘start of co-creation’ (see Figure 1). Step IV shows the clear focus of the SLR and determines the contribution of our research results to the lead-user method.

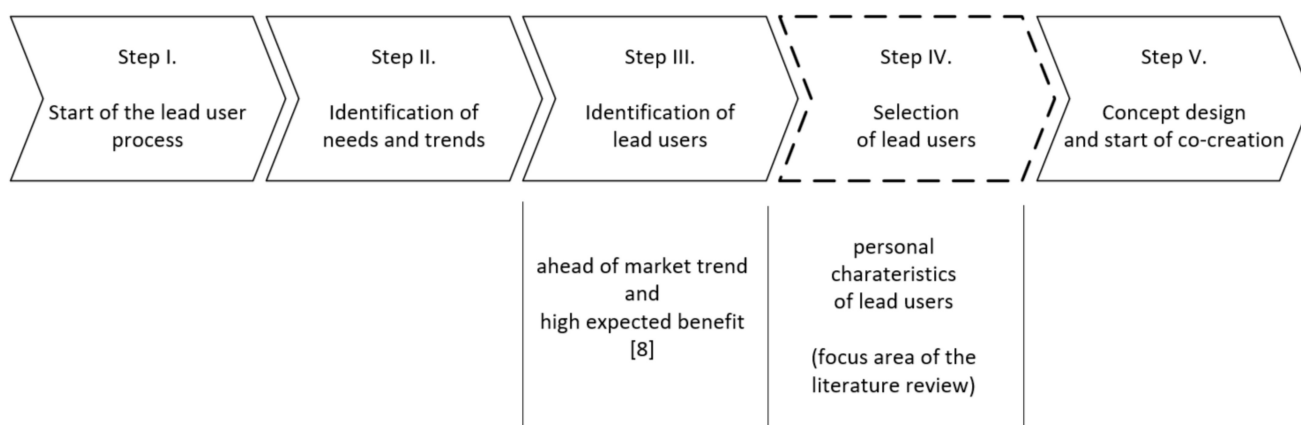


Figure 1. Extended lead-user method concerning the focus area of the literature review.

The research is also driven by the intrinsic motivation of the authors as one of them spent more than a decade in the high-tech industry as a manager and found that users’ brilliant ideas are valueless and no significant commercial success could be achieved if no proper personal characteristics are attached to the lead users during the open innovation process.

To perform our work effectively, we followed appropriate rigor and consistency and used an explicit and reproducible method. In the study, the authors followed the guidelines proposed by Refs. [40–42].

At this point of the study, we would like to make a note about the applied terminology of “customers” and “users”. Both expressions are used with identical value. The difference between them is the context in which they are used. In the industrial context, end users (named “users”) of a product use the product directly without making a purchasing decision, while users in the consumer context (called “customers”) use a product directly along with making also a purchasing decision. We use the term “user” in the industrial context and the term “customer” in the consumer context with an identical value. The

following section describes the literature review method, including the assessment criteria, search strategy, study selection process and quality assessment.

The systematic literature review consists of the following sub-elements: 1. identifying the review questions, 2. formulating the research method, 3. defining the inclusion and exclusion criteria, 4. implementing quality assessment and 4. synthesing the evidence to answer the research questions.

## 2. The Review Method

The review protocol describes and identifies the method to be applied to carry out a systematic literature review. The review protocol is an important step to minimize the possibility of researcher bias and avoid an analysis driven by the researcher’s expectations [42], and additionally to avoid fuzzy input that tends to lead to fuzzy answers. The review protocol contains all elements of the review method, including the research background and research question, study selection criteria, search strategy, quality assessment, extraction, and synthesis of the primary studies. Taking these factors as departure, our study reviews the research question and the research background as described above in the previous sections of this paper. The following sub-sections of our study contains the remaining listed elements of the review method.

### 2.1. Inclusion and Exclusion Criteria

The inclusion and exclusion criteria ensure that all selected primary research is pertinent and relevant to the study. The aim of our literature review is to understand the personal characteristics of the lead user, which enables a successful contribution to the co-creation process. Related to this stated research question, the review contains data from journal articles and conference proceedings available in full text, published in English in the identified databases between 2000 and 2020 in the domain of open innovation. The authors have excluded research articles with content unavailable in full text, research published outside of the identified time frame, research without proper description of data sources and methodologies, studies containing no relevant research results about the lead users’ personal characteristics, and papers containing only secondary research results. Table 1 covers all criteria for the literature review:

**Table 1.** Inclusion and exclusion criteria.

Inclusion criteria:	Available in full text
	Published between 2000 and 2020
	Written in English
	Related to the research question
	Within the searched domain of open innovation
	Published in the selected databases
Exclusion criteria:	Full text unavailable in electronic form
	Outside of the search timeframe
	Research without the description of data sources and methodology
	No information about lead user characteristics
	Papers with only secondary research results

### 2.2. Search Strategy

The search strategy involves both automatic and manual searches to explore a broader perspective of lead-user characteristics. The automatic search was an electronic search based on the defined keywords to address the research question of the SLR. Following the recommendation by [42], we conducted firstly the automated search for primary study references and secondly the manual search. Four online scientific databases were selected

as the main sources for the review: ScienceDirect, JSTOR, Scopus and Whiley Online Library. These databases provided the most relevant information for the domain related lead user’s characteristics. The used keyword string with the Boolean applied operators was: “lead-user” and “characteristics” and “new product development” and “innovation”. Although the word “co-creation” would theoretically lead to more accurate search results, the authors decided to exclude this keyword from the search string as the search had filtered out the relevant studies. After the first stage of the search process, we applied the manual search and utilized the forward and backward search process to track the references of the primary studies through manual reference scanning, which is the so-called “snowballing” method [43]. This process ensured a relatively complete systematic search, even though the primary search had not resulted in identifying relevant articles. Through the backward search, we manually scanned all the references of the current paper to find relevant studies which had not been found by the automatic search. The forward search found papers which confirmed, applied, extended, and improved the results of the referenced study. We used the Mendeley application for sorting all primarily and manually searched-for studies and removed duplicate studies.

The authors followed the review guidelines recommended by [42], which consist of three major parts, including planning, conducting and reporting the review. These stages consist of sub-elements, including 1. formulating the review question, 2. identifying the research method, 3. creating the inclusion and exclusion criteria, 4. performing quality assessment, and 5. synthesising the evidence to answer the research question. The backward and forward search and automatic search ensure that the systematic literature review is the relatively complete processing of the relevant literature [43]. The flow diagram (see Figure 2) presents both automatic and manual searches as well as the selection process with the search results.

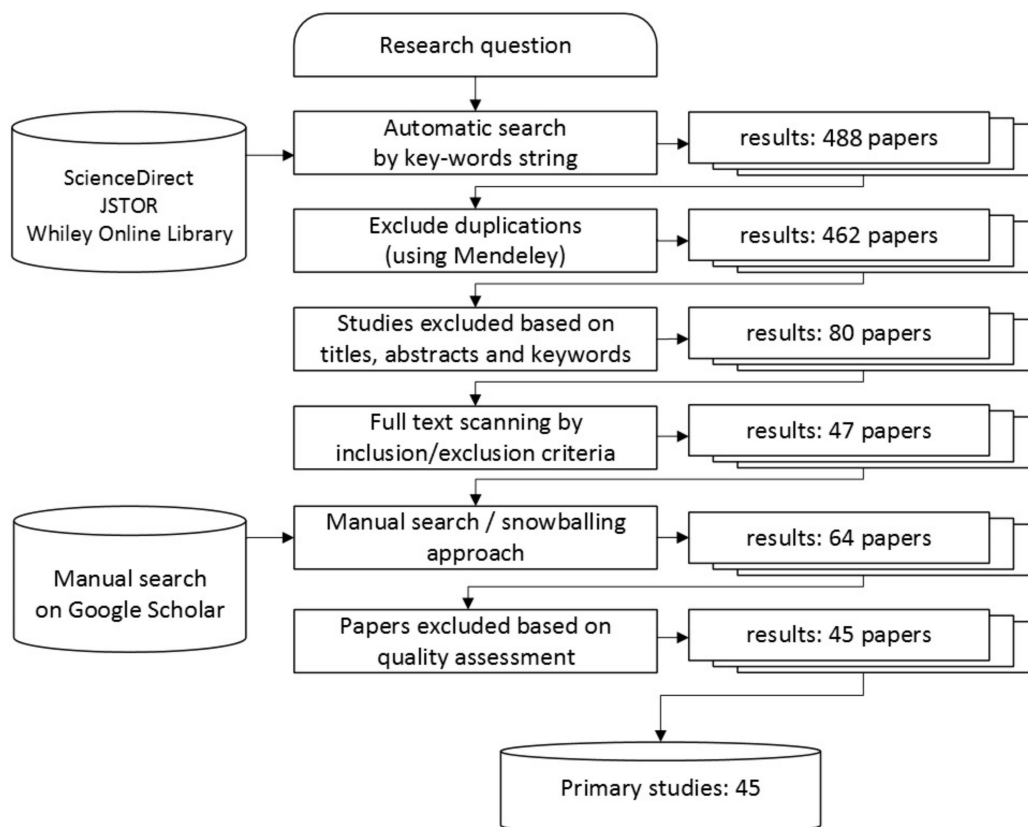


Figure 2. Flow diagram of the search and selection process.



### 2.3. Study Selection Process

The automatic search process resulted in 488 papers by utilizing the defined keywords. Four papers were found as duplicates, and they were removed by using the Mendeley application. The exclusion criteria were applied to the remaining 462 papers focusing on the title, the abstract and the keywords of the papers. The aim of this step was to classify studies accurately to eliminate the ones not in sync with the research question. The process led to 80 studies remaining. The initial automatic search brought about many papers unrelated to the research question. As recommended by [44], the authors maintained a list of excluded papers at this stage of the selection process. The next step involved reading the remaining studies to apply the inclusion/exclusion criteria, which culminated in 47 papers. Applying the manual and snowballing search methods on Google Scholar and utilizing the quality assessment led to 45 relevant studies.

### 2.4. Quality Assessment

The authors used a generic set of questions to evaluate the quality of each selected primary paper. This refers to a process of weighting the importance of each study when the results and the findings of selected primary studies are interpreted [44]. The authors conducted a quality assessment (QA) of the selected primary studies to fulfil the quality and accuracy criteria. Five QA criteria were formulated as Table 2 shows.

**Table 2.** List of the quality assessment criteria.

QA1:	Does the research investigate users’ characteristics?
QA2:	Does the type of cooperation refer to co-creation?
QA3:	Is the market domain accurately defined?
QA4:	Is the research about new product development?
QA5:	Are the research methodology and results accurately described?

The quality assessment questions were evaluated on each primary study to strengthen the researchers’ confidence about the overall quality of the selected papers. Table 3 shows the results of the QA process.

**Table 3.** Results of the paper selection process.

Results of the Study Selection Process	Initial Results	Relevant Studies
ScienceDirect	291	16
Scopus	12	0
JSTOR	39	2
Whiley Online Library	146	18
Google Scholar (second stage)	-	9
Summary:	488	45

The papers were graded by “high”, “medium” and “low” quality rankings. If the paper satisfied the criterion, then it was given a score of 1. If the paper partially satisfied the criterion, it was given a score of 0.5. If the paper did not meet the criterion, it was given a score of 0 [45]. According to the QA criteria and scoring process, the highest possible score is 5 (5 × 1) and the lowest possible is 0 (5 × 0). Studies scored between 4 and 5 were considered as high-quality papers, between 3.0 and 3.5 as medium quality and papers with a score of 2.5 as a low-quality paper. We identified nine low-quality papers (20%), seven medium-quality studies (16%) and 29 high-quality research articles (64%). QA ratings of each paper are listed in Table 4.

**Table 4.** Quality Assessment scores of primary studies.

SID	QA1	QA2	QA3	QA4	QA5	SUM	SID	QA1	QA2	QA3	QA4	QA5	SUM
S1	0.5	0	1	0.5	0.5	2.5	S24	0.5	0.5	1	0.5	1	3.5
S2	1	0	0.5	1	0	2.5	S25	0.5	0.5	1	0.5	1	3.5
S3	0.5	1	0	0	1	2.5	S26	1	0.5	1	0.5	1	4
S4	1	1	1	1	1	5	S27	1	0	1	0.5	1	3.5
S5	1	0.5	1	1	1	4.5	S28	0.5	1	1	1	1	4.5
S6	1	0.5	1	0.5	1	4	S29	1	0.5	1	0.5	1	4
S7	1	1	1	1	1	5	S30	1	0.5	1	0.5	1	4
S8	0.5	0.5	0.5	0.5	1	3	S31	1	1	1	1	1	5
S9	1	0.5	1	0.5	1	4	S32	1	1	1	0.5	1	4.5
S10	0.5	0.5	0.5	0	1	2.5	S33	0	0.5	1	0	1	2.5
S11	1	1	1	1	1	5	S34	0.5	0.5	0.5	0.5	0.5	2.5
S12	1	0.5	0.5	1	1	4	S35	1	1	1	1	1	5
S13	1	0.5	1	0.5	1	4	S36	1	0.5	1	0.5	1	4
S14	1	0.5	0.5	1	1	4	S37	0.5	1	1	0.5	1	4
S15	1	1	1	1	1	5	S38	1	1	0.5	0.5	1	4
S16	1	0.5	1	0.5	1	4	S39	1	0.5	0	0.5	0.5	2.5
S17	1	1	1	1	1	5	S40	1	0.5	1	1	1	4.5
S18	1	0.5	1	0.5	1	4	S41	1	1	0.5	1	1	4.5
S19	0.5	0	1	0	1	2.5	S42	1	0	0	1	1	3
S20	0.5	0.5	1	0.5	1	3.5	S43	0	0.5	1	0.5	1	3
S21	1	1	1	1	1	5	S44	1	0	1	1	1	4
S22	1	0.5	1	0.5	1	4	S45	1	0.5	1	0.5	1	4
S23	1	0	0.5	0	1	2.5							

### 2.5. Data Extraction and Synthesis of SLR

The data extraction form (Appendix A) accurately records all the information that the researchers have obtained from the primary 45 studies. To reduce the chance of bias, the data extraction form has been defined and it includes the following columns: study ID, title and authors, year of publication, context of the research, key findings, used methodology, countries and regions covered by the research, type of paper, data provider of the study, number of samples and the journal name (Table 5).

Following the systematic review, 45 papers as primary studies were finally selected that had been published within the investigated research field.



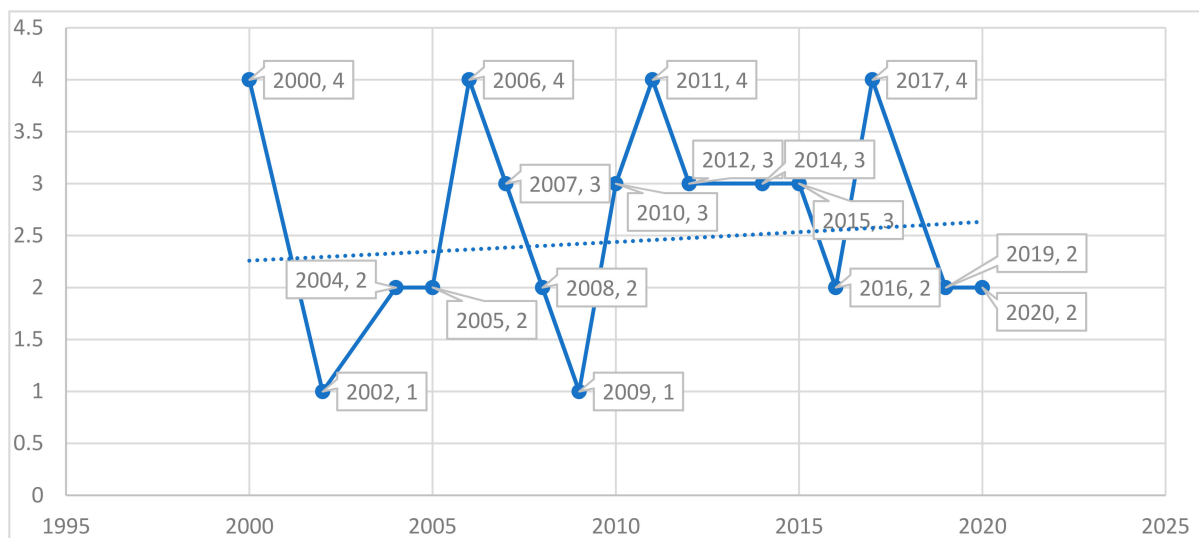
**Table 5.** Data extraction for primary studies.

Study ID:	Unique identifier of the study
Title and Authors:	The title and name of the authors of the study
Year:	The year of publication (between 2000 and 2020)
Context:	Identification of the product field (consumer, industrial, mixed, not available)
Key Findings:	The key findings of the paper
Methodology:	The used methodology in the research (quantitative, qualitative, mix)
Country:	The name of the countries covered by the research
Type:	The type of the paper (journal article, conference proceeding, book chapter)
Data Provider:	Name of the source the study was retrieved from
Number of Samples:	Number of samples used in the research
Journal Name:	Name of the journal the study was published in

### 3. Research Results

The review comprised 44 journal articles and one conference proceeding which was assessed as a high-quality paper. Multiple methodologies, i.e., qualitative, quantitative, and mixed ones, were applied. Out of the total 45 studies, 26 papers (58%) used quantitative methodology, 18 (40%) utilized qualitative methodology and one study (2%) employed mixed methodology.

Figure 3 shows the chronological distribution of the primary studies. The trendline indicates the increasing number of relevant studies related to the research domain of the personal characteristics of lead users.



**Figure 3.** Chronological distribution of the primary studies.

The SLR resulted in 33 studies concerning the consumer context and 12 studies regarding the industrial domain. Table 6 shows the journal names and rankings (source: [www.scimagojr.com](http://www.scimagojr.com), accessed on 22 December 2021) of the primary studies, indicating the number of studies retrieved from the journal.

**Table 6.** The name and ranking of the journals and the number of studies retrieved.

Name of the Journal	Ranking	Number of Studies
Creativity and Innovation Management	Q1	8
Journal of Product Innovation Management	Q1	6
R&D Management	Q1	4
Research Policy	Q1	4
Journal of Business Research	Q1	3
Journal of Engineering and Technology Management	Q1	3
Technovation	Q1	3
Information and Management	Q1	2
Management Science	Q1	2
Organization Science	Q1	2
California Management Review	Q1	1
European Journal of Management and Business Economics	Q2	1
International Journal of Innovation Management	Q2	1
Journal of Management Information Systems	Q1	1
Journal of Marketing Research	Q1	1
Marketing Letters	Q1	1
Technological Forecasting & Social Change	Q1	1

The new product development process is significantly different in the consumer and the industrial domain [27,46]. Considering this fact, the authors systematically distinguished the research contexts and separated the elements of personal characteristics in each stage of the NPD process. The characteristic elements of the lead users are shown in Table 7. The following sub-sections will provide insights on the personal characteristics of lead users in the subsequent stages of the NPD process: 1. idea generation; 2. concept generation and 3. prototype development and testino by answering the research question.

**Table 7.** Lead user personal characteristics in consumer and industrial context.

Stages of the NPD Process	References (Consumer Context)	Consumer Context	Both	Industrial Context	References (Industrial Context)
Development and test				technical expertise (positive impact)	[24,47]
	[23,48]		willingness to experiment and test		[24,47]
				technical expertise (negative impact)	[27]
Concept Development		optimism		tolerance for ambiguity	[24,47]
	[49]	openness to new experience		openness for new technologies	[24,47]
	[49]	verbal and visual processing styles		interdisciplinary know-how	[24,47]
	[50]	high technological reflectiveness		resources of research	[24,51]

Table 7. Cont.

Stages of the NPD Process	References (Consumer Context)	Consumer Context	Both	Industrial Context	References (Industrial Context)
Idea Generation	KNOWLEDGE AND EXPERIENCE				
	[17]		prior knowledge and experience		[47,52–54]
	[30,55]		need and solution knowledge		[24]
	[29,31,32]		product knowledge, use experience		[24,51–53]
	[17,33,56]		technical knowledge		[24,57]
	MOTIVATION AND WILLINGNESS				
	[23]		intrinsic motivation		[24,47,52]
	[58]	experienced empowerment		entrepreneurial mindset	[47]
	[31]	willingness to share ideas		motivation induced by problem	[24]
	[51]	willingness to collaborate			
	[31]	motivation driven by excitement			
	[51]	brand identity			
	CREATIVITY AND SKILLS				
	[29,32,49]			divergent thinking style	[24]
	[23,32,49]	creativity relevant skills		imagination capabilities	[24]
	[59,60]	betweenness centrality			
	[60]	age and cognitive capacity			
	BEHAVIOUR AND ATTITUDES				
	[34]	solution-oriented behaviour		financial attractiveness	[27]
	[34]	attention to other’s idea		trustworthiness, credibility	[57,58]
	[61]	early adaption mindset		personal level of interaction	[24,27]
				closeness of relationship	[27]

The length of the sub-sections is decreasing because of the following reasons. Firstly, firms involve lead users mainly in the fuzzy front end of the NDP process; therefore, scholars discuss mainly this stage of the NDP. Secondly, in the case of incremental innovations, firms do not require additional expertise from users as they apply their own technical expertise in higher stages of the NDP. In the case of radical innovations, companies involve users only with advanced technological skills in the development stage of the NDP. The number of capable users in higher stages of the NDP is decreasing as the higher levels require additional personal characteristics and they are more challenging to fulfil.

### 3.1. Idea Generation Stage

#### 3.1.1. Knowledge and Experience

Refs. [24,30] emphasize the importance of the users' prior technical knowledge, experience and skills as these elements determine the type of idea and the solution the user will develop. Users utilize their own "local" (tacit) stock of need and solution knowledge to develop innovative ideas and products. This repertoire is in line with the statement of [54], which argues that the discovery of a certain innovation opportunity is driven by the user's prior education, knowledge and work experience. Ref. [24] highlights the importance of in-depth professional knowledge and 'need knowledge' of medical surgeons as a crucial basis for innovative idea generation and solutions that meet specific needs.

This type of knowledge gained through experience, experimentation, and extensive learning is tacit; therefore, it is "sticky", difficult and costly to transfer to manufacturers [17,24,32,62]. Consequently, this may explain the reason why users develop radically new ideas instead of manufacturing firms that are more focused on incremental improvements [24]. Ref. [55] compares internal and external lead users and found that employees who possess 'need knowledge' are able to take advantage of the direct access to the organisation knowledge to work out their solution and they are more creative than an employee who lacks 'need-knowledge'. The same author additionally states that creativity-enhancing knowledge schemas (e.g., solution knowledge) and creativity-hindering knowledge schemas provided by a company may contain knowledge that increases the resistance to change. The same study also highlights that internal user ideas are easier to realize, while external user's ideas have maximum novelty, user value, and market potential.

Multiple studies find a positive effect of use-experience and product-related knowledge on the innovation activities of the users [17,29,31,51–53]. Ref. [33] emphasizes that technically savvy users are more likely to generate technically feasible ideas, while technologically innovative customers tend to provide radical or new product ideas. According to [57], the technical innovativeness of customers increases the intention of firms to involve them in the early stages of the NPD process.

#### 3.1.2. Motivation and Willingness

According to [23], a certain level of interest and task motivation is important in the idea generation phase to come up with new ideas, based on the evidence that creativity is driven by intrinsic motivation [63]. In contrast, Ref. [32] found that intrinsic and extrinsic motivation do not significantly describe the traits of lead users. In the consumer context, Ref. [31] examined the proportion of motivation-driven factors and found that 20% of the innovations are "need-driven" and 80% are "excitement-driven". The "need-driven" innovation is triggered by the perception of needs not yet fulfilled by the existing products on the market, while the "excitement-driven" innovators develop new ideas because of enjoyment, fun and pleasure, and less due to the desired outcome. This study also claims that community members are willing to share their innovative ideas with manufacturing firms free of charge. Ref. [51] expresses that willingness to collaborate and strategic alignment with brand identity are crucial characteristics of the users' innovativeness.

In the industrial context, Ref. [52] found intrinsic motivation as the main characteristic of lead users. Ref. [47] states that in terms of radical innovations in the medical domain, manufacturers are reluctant to invest in NPD, considering the design instabilities that trigger the users' entrepreneurial mindset to gain direct benefit from the tailored new technologies of their needs. The same authors emphasize that professional users experience difficulties in their daily work and they encounter the limits of conventional technologies, which motivate them to search for more workable solutions (motivation induced by problem). This strong intrinsic motivation supports creative activities [23,63] and enable innovations.

### 3.1.3. Creativity and Skills

Ref. [23] examines the impact of customer's creativity components at different stages of the NPD process. They found that users in the idea generation phase need to possess creativity-relevant processes, including extraordinary domain-relevant skills and an appropriate motivation level, heuristics, and work style to create creative ideas, while domain-specific skills have no impact on ideas. This finding was explained by the intention of companies being more interested to find and figure out a problem because they usually have strong abilities to develop and produce new products.

The research conducted by Ref. [60] among children shows that "betweenness centrality" (i.e., the bridging link between different social groups in a network) and age have a significant effect on creativity. Children can create more and better ideas with increasing age and cognitive capacity. According to their study, the favorable network position of children stimulates individuals to utilize the information advantage and to become creative. This is consistent with the research conducted among young adults as lead users [59].

In the industrial context and in the medical domain, Ref. [24] states that high problem pressure is the key source of creative activities. A divergent thinking style is the ability to "think outside of the box" and not being restricted by functional fixedness [32].

The close access to transdisciplinary know-how increases users' creative capacity [24]. Ref. [29] found that innate innovativeness explains creative achievements, including individuals who break "patterns of accepted modes of thought and actions" [64] (p. 623), and similarly, they "tend to take control in unstructured situations" (ibid) and are resistant to former standards and possess a risk-taking manner. The study also states that locus of control (LOC) [65] is a personal characteristic and a key element of creativity [66]. Moreover, they found that lead users possessing high internal LOC are likely to deal with new usage situations. They leave the solid terrain of the ordinary, usually commit to a difficult risky task and put effort into mastering improvements in existing products.

### 3.1.4. Behavior and Attitude

Ref. [34] investigated ideators' online behavior and they found that their value lies in solution-oriented behavior and paying attention to other's ideas. The solution-oriented behavior is more related to suggesting improvements on existing goods than suggesting ideas. The ideators, who are curious and open to other ideators' ideas, are more likely to be successful. Lead users with early product adaptation behavior are a valuable source of new ideas and additionally, they can successfully fuel the market diffusion process [61].

According to [58], empowered customers are more innovative through a co-creation IT tool, they feel trust and are willing to put effort into making a valuable contribution. Such a tool enables less-skilled customers and lower qualified users to participate in the virtual NPD task.

In the industrial context, Ref. [27] found that close customers and financially attractive customers yield a positive impact to the success of NPD, which relates to their market representation and reputation on the market. Additionally, they state that intensive customer interaction and close customers positively influence the product's success. In line with this statement, Ref. [24] underlines the importance of personal face-to-face interactions with users to develop and understand the user's complex and tacit information to be transferred. Ref. [27] found that personal interaction can increase the new product success during the early and late stages of the NPD, while the concept generation stages yield no impact. Appropriate skills for interaction need to be developed in radical innovation projects with respect to the users and firms. Ref. [57] claimed that in the collaboration process, firms require trustworthiness and credibility from customers otherwise they will ignore them.

### 3.2. Concept Generation Stage

Ref. [49] states that consumer innovativeness correlates positively with personality traits and processing abilities. Such customers, called “emergent nature customers”, possess unique capabilities to envision or imagine how new product concepts might be developed. These unique personality traits and processing abilities support the product concept stage, enhance the ability to process information visually and verbally, and they are open to new experiences, reflection, thinking styles, a high level of creativity and optimism. In contrast, Ref. [67] found that lead users and also average users outperform the “emergent nature customers”.

Ref. [50] states that technologically reflective customers demonstrate benefits in the concept generation and refinement phase. Technologically reflective customers can think about the impact of a product on its user’s society in general.

Ref. [23] finds that domain-specific skills (e.g., factual knowledge of the domain, familiarity, and technical skill) and creativity relevant processes have a lower impact on the concept generation in comparison with the idea generation. The authors also highlighted that task motivation has no impact on the concept development or on the prototype development.

In the industrial context, only a few studies have been found that investigate users’ characteristics in the concept development phase. Ref. [24] defines critical lead user characteristics including imagination capabilities, openness to technologies outside of the certain domain, and close access to an interdisciplinary approach. They all inspire creative thinking to develop state-of-the-art technologies. The availability of resources for research, e.g., time, human resources, and funds, are important individual and contextual factors in this stage of the NPD. Users without a supportive environment and available resources exhibited lower efficiency. Characteristics elements, such as problem-induced motivation, openness, and prior knowledge, play a crucial role at this stage of the new product development as well [24].

### 3.3. Prototype Development and Testing Stage

A limited number of studies have been found regarding the last stages of the NPD, i.e., prototype development, product development, and the testing stage.

In the consumer domain, Ref. [23] states that at this level of the NPD, the creativity-relevant processes and task motivation have no impact on the contribution of users, while domain-specific skills play an enhanced role in the users’ interest in experiencing and testing new products. Ref. [48] states that the willingness to experiment is crucial at this stage, which is aligned with the ideas of Ref. [24] as well.

In the industrial context, Ref. [24] realized that the characteristics of tolerance for ambiguity are essential to deal with uncertainty between the final output and benefit of the product. The author emphasizes the importance of technological competencies, such as mechanics, electronics, and computer programming, in cases of radical innovations. In contrast with this finding, Ref. [27] concluded that there is a negative performance impact of technically attractive users related to their contribution to the development of mid-range (innovations between minor and radical changes) innovations. They argued that companies rely on their own technical expertise and they shall not expect additional skills from users.

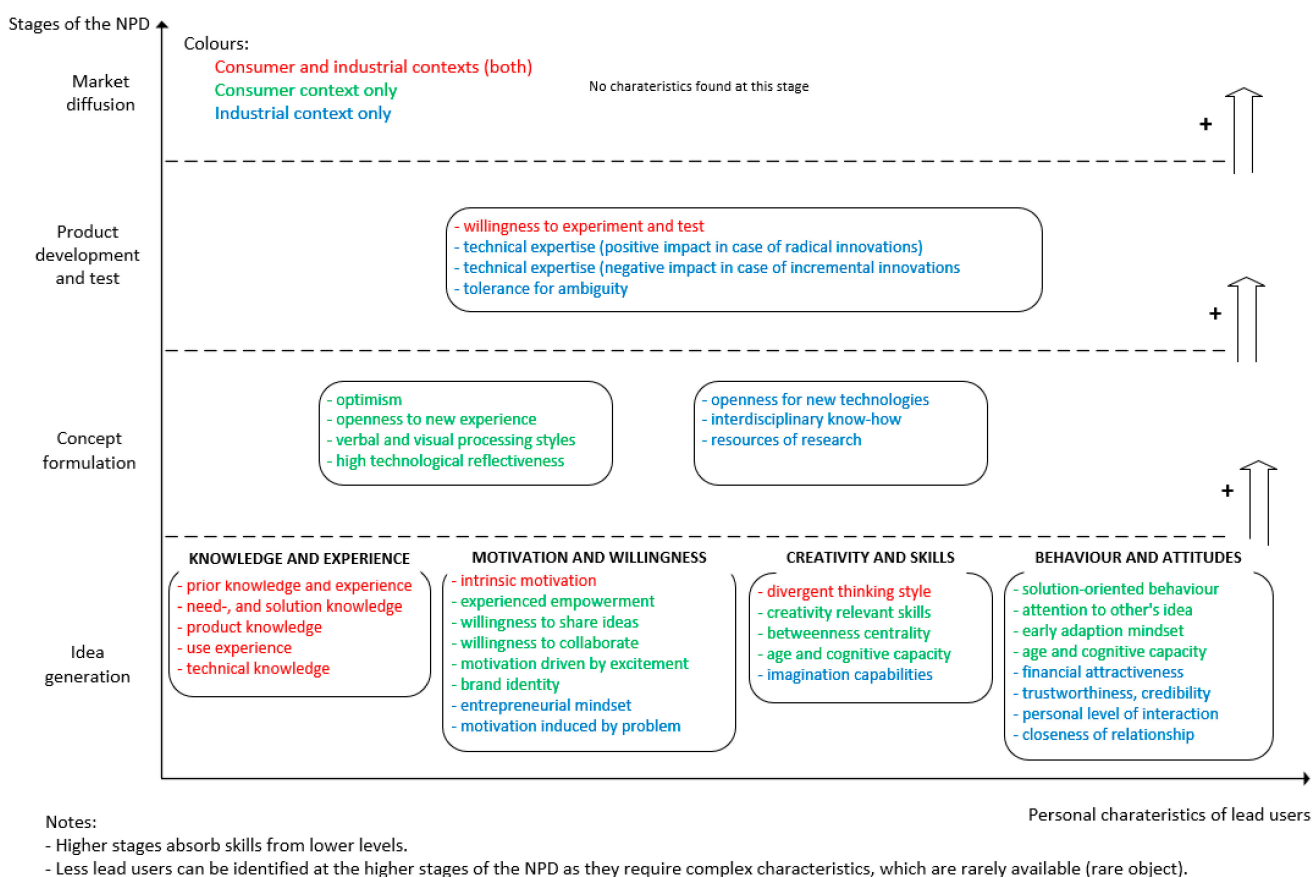
## 4. Discussion

Based on the above-presented systematic literature review, this paper has provided an overview of lead users’ personal characteristics related to NPD in case of co-creation. Altogether, 45 primary studies were found by performing the automatic and manual search processes, applying inclusion and exclusion criteria, and conducting quality assessment. The selected studies have been organized into two categories, i.e., consumer and industrial contexts, as they provide the key research settings of the studies. The majority of the articles, 73% (33 studies), were related to the consumer context and 27% (12) were to the industrial context. To fulfil the quality and accuracy criteria and strengthen the researchers’



confidence about the overall quality of the selected papers, the authors conducted a quality assessment process related to the primary studies. The assessment process resulted in 64% (29) high-quality papers, 16% (7) medium-quality papers and 20% (9) low-quality papers. To reduce the possibility of bias, the data extraction form has been defined (Appendix A) to record all information accurately that the authors obtained from the primary 45 studies.

To report the findings in a systematic way and provide an answer to the research question, we classified the NPD process into three stages, which are the following: 1. idea generation, 2. concept formulation, and 3. prototype and product development and test stages. We have found that most of the studies focus only on a fuzzy front end of the NPD process, and they discuss the personal characteristics of lead users only in connection with the idea generation stage. A limited number of studies have been found which discuss the characteristics in the later stages of NPD because fewer users are involved in the subsequent stages of the new product development process. The reason is that the number of capable users is decreasing as the higher levels require additional personal characteristics and they are more challenging to fulfil. We summarized the found personal characteristics elements in Figure 4.



**Figure 4.** Required personal characteristics of lead users in different stages of the NPD process.

We find significant differences in the consumer and industrial segments which shed light on the importance of context separation. This knowledge provides additional information for innovation managers to select the proper lead user for their co-creation process. The perspective of the market contexts provides complementary information and enables us to consider the required personal characteristics of lead users as a two-dimensional system: 1. personal characteristics in different stages of the NPD process and 2. personal characteristics in a dedicated market context. The differences are explained below and summarized in Table 8.

In the consumer segments, most of the lead users can be described as a hobbyist [29,47,68]. Firms utilize online IT tools to involve “low skilled users” without any face-to-face interaction [58,68]. The minority of lead users’ motivation is “need-driven” and the majority is “excitement-driven” [31] and experiment-driven [31,69] or simply driven by the enjoyment of the activity [30]. The type of innovations refers to incremental innovation [68] improvements, smaller changes [17,70] and can be characterized by low novelty [71]. Lead users can be identified in the early phase of the co-creation process [31]. The community membership and strategic alignment with brand identity have a positive impact on the motivation to interact [51]. Lead users in the consumer segment tend to earn free rewards. The innovation capabilities of lead users remain low, which corresponds to the required skills of firms in the consumer segment in the idea generation phase. According to [35], lead users in the consumer segments decide emotionally.

**Table 8.** Differences in the consumer and industrial segments.

	<b>Consumer Context</b>	<b>Industrial Context</b>
Type of Users:	hobbyist [29,47,68]	professionals [47,68]
Interaction/Participation	online user communities without face-to-face interaction [68]; application of IT tools for “low skilled users” to involve [58]	high level of personal interaction (face-to-face) [24,53]; the intensity of customer interaction varies in different stages of the NPD process
Motivation:	20% “need-driven” and 80% “excitement-driven” [31], enjoyment of activity [30], experiment-driven [31,73]	induced by needs and problems [24]
Type of Innovation:	incremental [68] improvements, smaller changes [17]; can be characterized by low novelty [71] and lack of users’ knowledge [35].	Radical innovation [24]
Identification of Lead Users Status:	in the beginning of the NPD process [31]	in later phases of the NPD process [24]
Needed Tools:	online tools	no tools
Belonging to Community:	motivates greater involvement and willingness to interact [51]	community membership does not impact willingness to become inventive
Brand Identity/Loyalty	strategic alignment with brand identity [51]	-
Reward:	Free	-
Innovation Capabilities:	Low	well-developed [24,72]
Decision Base:	emotional [35]	rational

In the industrial segment, most of the lead users are professionals [47,68]. The co-creation process requires a high level of personal interaction, but its intensity varies in different stages of the NPD process [53]. The motivation of lead users is triggered by needs and problems. Lead users in the industrial segments produce mostly radical innovations. The identification of lead users can happen in the later phase of the NDP process as lead users innovate during their everyday work [24]. Firms apply no tools to involve lead users in the co-creation. The innovation capabilities of lead users are well developed [72]. The decision base of lead users is mainly rational.

### 5. Contribution, Implications and Future Research

In conclusion, we state that the personal characteristics of lead users play a crucial role in the co-creation process, which varies in different stages of the NDP, separated into the consumer and industrial segments. The proper selection of lead users is essentially important as the quality of contribution highly influences the success of the open innovation process. This could result in a reduced time-to-market ratio and increased profitability.

Based on the results of the SLR and the key arguments, the authors made a contribution to the theory by extending the lead-user method with an additional step of “selection of lead users based on their personal characteristics”. With this extension, we emphasize the relevancy and impact of lead users’ personal characteristics on the entire co-creation process. The importance of the extension is confirmed by the identified 45 primary studies that strongly highlight the positive impact of proper lead users’ personal characteristics on the success of open innovation. We formulated the outcomes of the study in the form of a partial theory named “Lead User Cognition” (LuCog) which is an additional stage in the lead-user method between the steps of “identification of lead users” and “concept design and start of co-creation” phases as Figure 5 shows. The name of the partial theory (LuCog) conveys the essence of the extension as it aims to express the relevance of the lead user cognition process of decision makers during the lead user selection process.

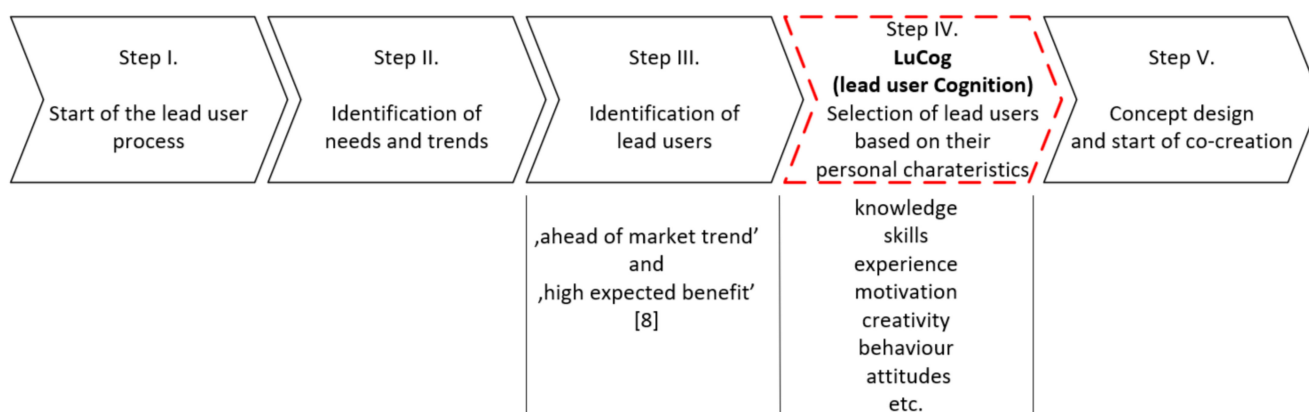


Figure 5. The extended lead-user method.

The review also provides a contribution to practice as managers can make a better selection of external contributors (lead users) during their open innovation process. The extended version of the lead-user method provides a crucial tool for decision-makers to select the right lead users for certain stages of the NPD process. The more accurate selection of lead users leads to higher innovation productivity and allows us to reduce development cost and time, shorten the time-to-market factor and help firms to realize a higher profit.

The study has some limitations as the users’ characteristic elements have been investigated only on the individual level. Two characteristic elements, such as “ahead of market trend” and “high expected benefit”, were eliminated from the investigation as the lead-user method contains it in step three (Figure 1). Moreover, we have also omitted the big five personality traits, which were investigated by [74].

Although the Lead-User Theory and Method was created by Eric von Hippel in 1986, the authors decided to review studies published between the time frame of 2000 and 2020 for the following reasons. First, scholars started to reflect on the importance of personal characteristics of lead users only after 2000. Second, the application of the snowballing approach during the study selection process by a manual scan of all references of the primary studies results in relevant studies which may not be covered by the automatic and manual searches.

The snowballing search offered an opportunity to take into consideration the synonyms of the word “characteristics”, e.g., characteristic, attribute, skills, and abilities. We have included all studies that have used any of the synonyms of characteristics and fulfilled the substantial aims of the SLR.

Scholars have generally focused so far on some high-tech industries and consumer products, where lead users are attractive and therefore easy to recognize their activities. Little attention has been paid so far to the role of lead users’ personal characteristics in the hidden domains such as healthcare instruments and tools development or agriculture. Different market contexts require different characteristics which open new perspectives. Further research goals can be derived from the different considerations of our LuCog method. It can be interpreted as the cognition process of managers during their selection process in the fuzzy front end of the co-creation process and also can be understood as a cognition process of lead users by choosing the right firm to co-create. Both topics are neglected in the academic literature.

In sum, further research results in different contexts can lead to a better understanding of the selection criteria of lead users as well as those management techniques which could be applied in open innovation processes. New results facilitate the process wherein managers open their company boundaries in order to tap lead users’ product-related ideas, knowledge, and experience. They can better exploit the advantage of open innovation and adjust open innovation dynamics to changing market conditions and customer needs.

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**Data Availability Statement:** Details of the 45 primary studies selected are included in this paper.

**Conflicts of Interest:** The authors declare no conflict of interest.

**Appendix A**

**Table A1.** Data Extraction Form.

SID	References	Context	Key Findings	Method	Country	Type of Paper	Data Provider	Number of Samples (n)	Journal Name
S1	[25]	industrial (B2B manufacturing of marine vehicles, power plants)	The paper differentiates customer and user knowledge. End-users use the product but do not make a purchasing decision. The customers buy the products but do not use them directly. User knowledge is often tacit and sets long term development goals. Customers can provide explicit knowledge to reach short term needs.	qualitative (holistic case study)	-	Journal	ScienceDirect	30	Information and Management
S2	[75]	consumer	The paper reveals some characteristics of lead users as a crucial factor of online identification of lead users: being ahead of trend, high expected benefit, user expertise and motivation, extreme user needs, opinion leadership and online commitment.	qualitative (review)	-	Journal	ScienceDirect	-	International Journal of Innovation Management
S3	[76]	consumer	The study states that participation in online communities can be a new indicator and potentially effective criteria of assessing lead user potential which can be effectively discovered through social media by netnography and crowdsourcing.	qualitative (case study)	-	Journal	ScienceDirect	24	Journal of Engineering and Technology Management
S4	[77]	industrial (machine engineering)	The study describes the case when a company follows all the steps that lead-user theory recommends but the project fails. The reason is that companies may not understand when and how to use the lead-user method to reduce the risk of innovation and market. The selection and customer integration need a skilled person. The integration shall involve steps as 1. finding customers with the right knowledge, 2. selecting the right customer category, 3. customer integration in the early phase, 4. keeping high the project team motivation for integrating customers.	qualitative (case study)	Europe and Asia	Journal	Wiley Online Library	50	Creativity and Innovation Management

Table A1. Cont.

SID	References	Context	Key Findings	Method	Country	Type of Paper	Data Provider	Number of Samples (n)	Journal Name
S5	[32]	consumer (kitchen appliances)	The study determinate characteristics which are related to lead usersness: 1. individual creativity and personality play an important role in the deterministic of lead usersness; 2. domain-relevant skills (product-related knowledge and use-experience) and creativity-relevant skills (divergent thinking style) are related to lead usersness; 3. intrinsic motivation. Individual creativity can be explained by personality-related characteristics.	qualitative (empirical study)	Germany	Journal	Wiley Online Library	146	Creativity and Innovation Management
S6	[78]	consumer (kite surfing)	The study confirms that the “high expected benefit” dimension leads to higher innovation likelihood and the “ahead of trend” dimension predict innovation likelihood and commercial attractiveness of the innovation developed by the user. Technical expertise and community-based resources are recommended as search criteria next to the two lead-user components.	quantitative	Europe	Journal	Wiley Online Library	456	Product Innovation Management
S7	[79]	consumer (sportswear)	The paper finds that active and strong ties between customer and company support significant innovation. This opportunity can lead to better innovation only when a firm builds proper co-creation capabilities.	qualitative (case study)	Germany	Journal	Wiley Online Library	-	R&D Management
S8	[80]	consumer	The researchers identify four different kinds of users engaging in co-creation: intrinsically interested, curiosity-driven, need-driven, reward oriented.	qualitative (empirical study)	-	Journal	Google Scholar		California Management Review
S9	[81]	consumer (Swarowsky design competition)	The study highlights that former co-creation experience has a significant impact on the quality of submitted designs.	qualitative (case study)	global	Journal	Google Scholar	298	R&D Management



Table A1. Cont.

SID	References	Context	Key Findings	Method	Country	Type of Paper	Data Provider	Number of Samples (n)	Journal Name
S10	[31]	consumer (basketball shoes)	The study states that only very knowledgeable members of the community are innovative and modify existing or create new basketball shoes. They are willing to share their ideas with the sports equipment manufacturer companies. The success of virtual integration depends on the community's innovation potential and the consumer's willingness to participate. These innovators are 20% "need-driven" and 80% "excitement-driven".	qualitative (netnography)	Germany	Journal	ScienceDirect		Journal of Business Research
S11	[23]	consumer (virtual NPD project)	The research finds that the impact is asymmetrical between the consumer's ability to generate ideas and to develop new products. The threshold levels of domain-specific skills, creativity-relevant process and task motivation are investigated at different stages of product development as idea generation, evaluation of product concepts and interest, testing new products and interest in co-creation.	quantitative	n/a	Journal	Wiley Online Library	825	Creativity and Innovation Management
S12	[58]	consumer (NPD project from ten different fields)	The paper presents an Internet-based tool that contributes to customer empowerment in virtual new product co-creation activities. Lead users have a higher need to express their knowledge and to articulate their needs. The co-creation tools make stronger feelings of empowerment of customers.	Quantitative	-	Journal	Wiley Online Library	727	Journal of Management Information Systems
S13	[11]	industrial (healthcare)	The study investigates the link between user and manufacturer interaction and finds that lead users not only help a firm to understand the problem but they can also provide a solution for them.	Quantitative	Germany and UK	Journal	ScienceDirect	243/146	Technovation

Table A1. Cont.

SID	References	Context	Key Findings	Method	Country	Type of Paper	Data Provider	Number of Samples (n)	Journal Name
S14	[82]	consumer (financial/IT)	The paper states that different forms of external knowledge contribute differentially to knowledge creation.	Quantitative	USA/Singapore	Journal	ScienceDirect	399	Information and Management
S15	[27]	industrial (machinery industry)	The paper states that customer interaction has a positive impact on product success during the early and late stages of NPD process while interaction in the middle stages has no performance impact. Technically attractive customers have a negative impact on NPD explained by different effects. Financially attractive customers, lead users and close customers have a positive impact as attractive partners in NPD.	quantitative	Germany	Journal	ScienceDirect	310	Journal of Business Research
S16	[52]	industrial (healthcare)	The paper states that the high level of expected benefit, the frequent use of information and intrinsic motivation show significant differences between non-lead users and lead users. The research was performed in medical surgery in Turkey.	quantitative	-	Journal	Google Scholar		European Journal of Business and Management
S17	[67]	consumer (game of chance sector)	The article critically reflects the concept of Emergent-Nature Consumers (ENC) [49]. The research states that the lead-users outperform ENC and remain as a primary source of innovations.	quantitative	French	Journal	Wiley Online Library	53	Product Innovation Management
S18	[49]	consumer (home SmartBox)	The paper states that product concepts developed by customers with high emergent nature (openness to new experience, reflection, verbal and visual processing styles, experimental and rational thinking style, creativity, and optimism) ultimately lead to greater sales compared to products that are developed by other types of customers.	quantitative	global	Journal	JSTOR	1124	Journal of Marketing Research

Table A1. Cont.

SID	References	Context	Key Findings	Method	Country	Type of Paper	Data Provider	Number of Samples (n)	Journal Name
S19	[68]	consumer (music instruments)	The research investigates the key personal attributes of customers which responsible for innovations. Innovative users are hobbyists (there is a willingness to share innovations) or responsive for “firm recognition” to undertake innovation. It has been also found that innovative users are like to be lead users which positively impact the quality of innovation.	multiple methods	-	Journal	Google Scholar	345	Organization Science
S20	[60]	consumer (school groups of children)	The study found that users with betweenness centrality (boundary-spanning position) are able to create highly novel ideas in the idea generation phase. The betweenness centrality also determinates creativity by minimizing communication barriers. A positive correlation has been found between being creative and lead user.	quantitative	Netherlands	Journal	Wiley Online Library	45	Creativity and Innovation Management
S21	[59]	consumer	Lead users are positioned as bridges between different social groups which can be mapped by modern online mining tools quickly and low in cost and help companies to increase the effectiveness and efficiency of lead-user identification.	quantitative	Netherlands	Journal	Wiley Online Library	267/3118/50	Product Innovation Management
S22	[57]	industrial (OEM manufacturer)	The paper found that customer’s promise, interdependence technological innovativeness and supplier technical capability positively influence the intention of early supplier involvement in the NPD process.	quantitative	USA	Journal	ScienceDirect	422	Journal of Business Research
S23	[24]	industrial (health-care)	The study investigates users’ characteristics at different stages of product development in the field of medical technology in case of radical innovations.	qualitative (case study)	-	Journal	ScienceDirect	45	Journal of Engineering and Technology Management

Table A1. Cont.

SID	References	Context	Key Findings	Method	Country	Type of Paper	Data Provider	Number of Samples (n)	Journal Name
S24	[47]	industrial (medical)	The study investigates the characteristics of capable users at different levels of their contribution to radical innovations in the field of medical equipment technology. They have high motivation to search for new solutions, own a diverse set of competencies, embedded in a supportive environment, and play an entrepreneurial role.	qualitative (case study)	-	Journal	Wiley Online Library	36	R&D Management
S25	[13]	industrial (3M)	The paper compares the lead user (LU) idea generation process with conventional methods and finds that the ideas generated by the LU process have a positive impact on the sales revenue, have a significantly higher novelty and more original compared with traditional methods.	quantitative	-	Journal	Google Scholar	47	Management Science
S26	[17]	consumer (outdoor sport products)	The paper states that the motivation of users to innovate is driven by their specific not fulfilled needs and by the realized discrepancy between the experienced and expected performance of the products. Approximately 9% of the sample users built prototypes or marketable products and do it without contacting a firm to transfer their ideas, concept or prototypes.	quantitative	Germany	Journal	ScienceDirect	153	Technovation
S27	[30]	consumer (mountain bikes)	The study shows that a user's personal patterns of product usage ("local" information) highly influence the functionality of innovative ideas. The type of solution is determined by the technical knowledge and skills of the user. It offers that a fundamentally different approach of lead user identification might be possible when firms identify lead users with a specific type of needs (safety mountain bikes shall be developed with bikers who have a high need for safety).	qualitative (empirical study)	North America	Journal	Google Scholar	287	Research Policy

**Table A1.** *Cont.*

SID	References	Context	Key Findings	Method	Country	Type of Paper	Data Provider	Number of Samples (n)	Journal Name
S28	[53]	industrial (various domains)	The paper states that the customers' knowledge and its novelty, the customer–firm closeness and the type of communication channels are impact factors of the success of customers co-creation initiatives.	quantitative	Europe	Journal	Wiley Online Library	126	Product Innovation Management
S29	[51]	consumer (motorbike)	The study states that willingness to collaborate has a high impact, while product knowledge and strategic alignment with the brand identity has a moderate effect on innovativeness in online brand communities.	quantitative	global	Journal	ScienceDirect	572	Technovation
S30	[61]	consumer (libraries)	The study highlights the values of lead users as early adopters, sources of new ideas, research potential and the role of promoting the process of diffusion.	quantitative	Australia	Journal	ScienceDirect	432	Research Policy
S31	[71]	consumer (OPAC library information systems)	The study determinates the characteristics of users who modify the system and share information about it. Innovating users more likely to share their innovations with others.	quantitative	Australia	Journal	JSTOR	122	Management Science
S32	[83]	consumer (sport goods)	The article introduces a toolkit for idea competitions (TIC) to access user's innovative ideas and solutions and which encourage users to participate in the open innovation process and increase the quality of their submissions.	quantitative	Germany	Journal	Wiley Online Library	82	R&D Management
S33	[48]	consumer (high-speed broadband network)	The paper examines advanced users (lead users) by their characteristics, adoption behavior and contribution to innovation.	quantitative	Netherlands	Journal	ScienceDirect	673	Technological Forecasting & Social Change

Table A1. Cont.

SID	References	Context	Key Findings	Method	Country	Type of Paper	Data Provider	Number of Samples (n)	Journal Name
S34	[84]	consumer (various)	The study compares the product innovation practices of two in-house developers (HILTI, Buechi) and two development contractors (IDEO, Tribecraft). It states that customer contribution is high in in-house developers while it remains at a low level in the case of development contractors.	qualitative	Northern Europe	Journal	Wiley Online Library	-	Creativity and Innovation Management
S35	[35]	industrial development of PCB (printed circuit board) quality tester	The study examines the process of product failure. Ostensible customers seem to offer benefits (motivation to solve problems, suggestions for improvements, experience sharing), but their value misleads due to lack of knowledge, vaguely expressed wants and no real intent to purchase.	qualitative	French	Journal	ScienceDirect	19	Journal of Engineering and Technology Management
S36	[34]	consumer (digital services)	The research states that ideators with solution-oriented behavior (idea + solution) and positive attention to other ideator's idea are likely to suggest ideas which can be implemented.	qualitative	Germany	Journal	Wiley Online Library	48	Creativity and Innovation Management
S37	[29]	consumer (extreme consumer sport fields)	The study extends the lead user theory with field-related variables (consumer knowledge, use experience, locus of control and innovativeness) as antecedents and adaptive behavior as consequences. All observed variables support the characteristics of lead users.	quantitative	global	Journal	Wiley Online Library	129/193/139	Product Innovation Management
S38	[56]	consumer (kite surfing, tech diving)	The study finds that lead users have high domain-specific innovativeness, perceive new technologies as less complex and therefore adopt new products early. Lead users have stronger opinion leadership and lower opinion seeking characteristics.	qualitative (case study)	-	Journal	Google Scholar	139/143/193	Marketing Letters



Table A1. Cont.

SID	References	Context	Key Findings	Method	Country	Type of Paper	Data Provider	Number of Samples (n)	Journal Name
S39	[85]	consumer (online services of soccer clubs)	The study investigates the context of new service development. It has been found that ahead of trend, expertise, consumer knowledge, and extrinsic motivation has a negative impact while dissatisfaction, intrinsic motivation has a positive impact on idea quality. The research states that the characteristics of lead users do not directly create creative output.	quantitative	-	Journal	Wiley Online Library	120	Creativity and Innovation Management
S40	[18]	consumer (various)	The study describes six user types based on five dimensions and proposes a guideline for optimal integration of users.	qualitative	-	Conference proceedings	Google Scholar	-	ISPIM 22nd conference: Sustainability in innovation: innovation management challenges
S41	[54]	consumer (home appliance)	The study states that external user ideas have maximum novelty, user value, and market potential, while internal user ideas are more easily realizable compared to ordinary users.	quantitative	Germany	Journal	ScienceDirect	864/239	Research Policy
S42	[86]	consumer (mountain engineering industry)	The study tests and supports the hypothesis that embedded lead users (employees who are lead users of their employing firm's product or services) foster innovation at work.	quantitative	Germany/ Switzerland/ Italy	Journal	ScienceDirect	149	Research Policy
S43	[33]	consumer (smart home)	The study states that users with high technical skills lead to technically feasible ideas. Trend-aware and technically innovative users produce ideas of greater originality, while ethically reflective users have ideas with a positive impact on society.	quantitative	-	Journal	Wiley Online Library	93	Creativity and Innovation Management

Table A1. Cont.

SID	References	Context	Key Findings	Method	Country	Type of Paper	Data Provider	Number of Samples (n)	Journal Name
S44	[50]	consumer (health monitoring system)	The paper systematically develops a multi-item scale to measure the level of technological reflectiveness (TR) of an individual. External sources with high TR scores can contribute to the early stages of the innovation process.	quantitative	-	Journal (PIM)	Wiley Online Library	-	Product Innovation Management
S45	[54]	industrial (3D printer)	The study states that individuals can discover opportunities through recognition rather than search. Individuals with prior knowledge developed through education and work experience will more likely discover innovation opportunities than people without prior knowledge.	qualitative (case study)	USA	Journal	Google Scholar	22	Organization Science

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